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September 1941

UNITED STATES
DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

BUREAU OF MINES
R. R. Sayers, Director

INFORMATION CIRCULAR

MARKETING GRAPHITE

BY

Paul M. Tyler and Charles L. Harness

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I.C. 7177,
September 1941.

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MARKETING GRAPHITE[1]

By Paul M. Tyler[2] and Charles L. Harness[3]

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KINDS OF GRAPHITE

Graphite is chemically identical with diamond, both being crystallized allotropic forms of carbon. Graphite obviously differs greatly from diamond in physical properties and is easily recognized by its blackness, its softness (1 to 2 on Mohs' scale), and its slick feel when rubbed between the fingers.

Strictly speaking, all graphite is crystalline, but grades in which the individual grains cannot be distinguished with the naked eye are commercially classed as amorphous. Natural mixtures of the two varieties occur in all proportions, and the classification of a given sample as "amorphous" or "crystalline" graphite is based largely upon trade practice. Until recently different varieties of vegetable or animal charcoal, lamp black, soot, gas carbon, and coal were considered strictly amorphous, but modern examination by X-ray methods indicates that even these materials possess the same internal crystalline structure as graphite, differences in physical properties being perhaps explained by porosity or presence of combined hydrogen or other impurities.

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[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7177."

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Crystalline graphite is subdivided into (1) flake, (2) lump or vein (plumbago), and (3) dust. In commercial practice, however, dust is considered about the same as amorphous graphite and has the same uses.

Amorphous graphite, in addition to occurring naturally, is made in electric furnaces with a charge of petroleum coke (or anthracite), sawdust, and silica. The high temperature volatilizes the impurities, leaving a residue of artificial graphite. Most of the output of manufactured graphite is in the form of graphitized electrodes and other finished articles, but a substantial and slowly growing tonnage in recent years has been marketed in powdered form, competing with natural amorphous graphite.

OCCURRENCE

Foreign Sources

Deposits of unusually large and tough crystalline flake occur in a belt 400 miles long on the French-owned island of Madagascar. Even before concentration the material, though varying widely in composition, is fairly high grade, averaging 10 to 12 percent graphitic carbon. Reserves are virtually inexhaustible. Concentrates contain over 85 percent graphitic carbon with a particle size of 20- to 60-mesh and an apparent density of about 0.8. Since this grade of graphite is employed in the manufacture of metallurgical crucibles and since it hitherto has been produced commercially only in Madagascar, it is classed by the United States national defense agencies as a "critical" mineral.

Vein graphite is also used to some extent in crucibles. This variety, also known as lump or chip graphite or plumbago comes from Ceylon, where it occurs as large, thick plates in veins that range in width up to 6 feet. In narrow veins it may have a comb or fibrous structure, yielding the more valuable needle lump. Veins worked to a depth of 600 feet show no marked change in graphite content, and reserves are universally believed to be enormous. Lump graphite ranges from the size of walnuts down to that of a pea and runs about 90 percent carbon. Ceylon chip graphite ranges in size from that of a pea to a little smaller than wheat grains.

Dust graphite is comparable in grain size to gunpowder, or about 40- to 60-mesh, and contains 55 to 80 percent carbon. It is produced in both Ceylon and Madagascar and retains certain characteristics of larger particles of like origin.

Good-quality amorphous graphite occurs as beds in sandstone in Sonora, Mexico, and in Chosen (Korea) as beds and irregular lenses, mainly in the central and eastern parts of the country.

Domestic supplies of graphite are drawn principally from Ceylon, Madagascar, Mexico, and Chosen. Canada, however, normally supplies all imports of artificial graphite, usually less than 1,000 tons a year, and as much as 300 tons of flake and somewhat larger quantities of "amorphous" or ultrasmall flake graphite.

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The world's largest sources of graphite are in central Europe, but the material is mostly too low-grade for export overseas. Actually graphite has been mined in almost every country in the world from Greenland (60 tons in 1937) to South Africa (69 tons in 1937); yet Ceylon and, in later years, Madagascar have been the only countries that have been able to get prices for their raw graphite sufficiently high to permit it to be shipped to industrial nations all over the world. Even Korean (Chosen) graphite has a rather limited market, and Mexican graphite, notwithstanding its purity, is shipped only to the United States. Of a total world output of about 200,000 metric tons in 1940, the U.S.S.R. was credited with furnishing over 40 percent; Germany and Austria combined, over 20 percent; Chosen, 20 percent; and Mexico, 5 percent. However, the bulk of the product of these countries is low-priced amorphous graphite, much of which is used only locally. Although the tonnage mined in Ceylon and Madagascar seldom exceeds 15 percent of the world total, the value of their output is probably at least half of the total.

Domestic Sources

In recent years the production of crystalline graphite in the United States has been insignificant, and the natural amorphous graphite output has been confined to a few hundred tons annually. At Cranston, near Providence, R. I., part of an anthracite bed has been graphitized, furnishing a low-price ingredient of foundry facings; graphitic slates near L'Anse, Baraga County, Mich., and a deposit south of Carson City, Nev., have been operated more or less regularly for many years as sources of paint material, and at various times low-grade amorphous graphite has been produced in Georgia and other States. No really high grade amorphous-graphite deposits are known to have been worked in this country.

Lump graphite resembling that produced in Ceylon has been mined near Dillon, Mont., but never in large amount.

Crystalline flake graphite is found in schists or limestones in various States and has been mined in New York, Pennsylvania, Alabama, Texas, and California. Since 1930, about the only production of flake has been in Los Angeles County, Calif., and beginning in 1938 from a newly opened region in St. Lawrence County, N. Y. Mines in the Llano-Burnet region of Texas were closed about 1930.

During the World War of 1914-18 much of the expanded domestic output came from Alabama, where at one time 30 plants were in operation and 10 more under construction. In 1917 the total output of natural graphite in the United States reached 13,593 tons, but despite greatly increased tariff duties under the Tariff Act of 1922 and strenuous efforts to maintain or revive the mining industry, especially in Alabama, American consuming industries were subsequently supplied almost wholly by imports. Domestic resources of flake graphite are undoubtedly enormous and could be brought into production quickly. However, the ores contain relatively small percentages of graphite, and, more important, the flake that they yield by concentrating has never proved readily salable except for the brief period in the World War of 1914-18, when the preferred qualities from Ceylon and Madagascar were difficult to obtain. If the flake concentrates from domestic ores could be marketed in fair quantities at prices comparable to those obtainable for Madagascar flake, production in Alabama and certain other States might prove profitable, even under normal conditions. Early in 1941 the Bureau of Mines was investigating the possibility of producing concentrates from certain Alabama ores that would be an acceptable substitute for Madagascar crucible flake.

USES

According to reports of graphite consumers and dealers to the Bureau of Mines in 1938, approximately 30 percent of the total graphite consumption was devoted to foundry facings, core washes, and similar uses. About 30 percent was consumed in dry batteries. Crucibles, lubricants, and pencils consumed about 10 percent each. Three percent was consumed in paints and stove polishes, 1 percent in commutator brushes, and the remainder in a large number of miscellaneous products and processes.

When metals are cast in a sand mold some of the sand will stick to the metal unless the surface of the sand has been given a facing of graphite, talc, mica, or similar material. Facings containing graphite or other carbonaceous matter are commonly called "blackings." The grade of graphite that may be employed in a foundry facing ranges from impure amorphous to high-quality flake. It is by no means established that the higher grades are superior, as impurities ordinarily are added to form an adhesive bond.

The fair thermal conductance and high melting point of graphite qualify it for a number of refractory uses, the most important of which is the manufacture of crucibles for melting steel and nonferrous metals. For this purpose, Madagascar flake is mixed with refractory clay (German Klingenberg clay is preferred) and grog (burnt clay, silicon carbide, etc.), the mixture containing usually 40 to 50 percent graphite. Before 1917, Ceylon lump and chip were used predominantly for this purpose, but modern crucibles made from Madagascar flake and improved batch formulas can withstand two or three times as many heats as the best crucibles manufactured in 1914-18. Stoppers, ladles, and retorts for the recovery of secondary zinc are similarly made. The consumption of crucible graphite has declined for several reasons. The increasing use of the electric furnace for melting steel and the open-flame furnace for melting nonferrous metals has decreased the demand for graphite crucibles. No steel ingots have been made by the crucible process for more than a decade. Modern crucibles are larger and so hold more metal per heat; and improved methods of manufacture, including the use of Madagascar flake graphite, have increased the number of melts obtained from each crucible.

X-ray data indicate that graphite crystals are built up of innumerable tiny hexagonal plates that slide easily over one another if a small shearing force is applied. This property makes graphite seem greasy when rubbed between the fingers and explains its lubricating qualities. Graphite is especially useful in lubricating the bearing surfaces of heavy machines, as it clings to the metal surface and is not squeezed out of the interface at high bearing pressures. For this purpose it is generally applied in an oil or grease vehicle, although small quantities are used in oil-less bearings for slow-speed machinery. All varieties of graphite have been used in lubricating compunds. Obvious requirements are high purity and freedom from grit.

TABLE 1.- World production of natural graphite, 1915-34 (5-year averages), 1935-37 (3-year average), 1938, and 1939, in metric tons

Country	1915-19 (average)	1920-24 (average)	1925-29 (average)	1930-34 (average)	1935-37 (average)	1938	1939
Argentina.......	-	-	-	-	14	28	-
Australia:							
New South Wales	100	18	12	18	10	-	(1)
Queensland.....	-	-	-	-	16	10	(1)
South Australia.	-	-	-	15	(2)	-	-
Brazil 3/.......	13	10	4	4	4	(1)	(1)
Bulgaria........	-	-	-	-	-	-	23
Canada..........	2,481	1,172	1,756	790	(4)	(4)	(4)
Ceylon 3/.......	21,042	9,088	13,618	8,677	15,174	11,972	22,756
Chosen 3/.......	7,679	15,034	18,484	23,721	42,937	50,348	78,501
Czechoslovakia..	5/26,841	13,751	29,276	4,187	3,313	(1)	(1)
France..........	886	415	734	46	-	(1)	(1)
Germany:							
Austria........	6/19,657	11,557	19,083	14,653	19,786	16,852	(1)
Bavaria........	31,308	21,696	17,548	21,333	23,166	28,106	(1)
Greenland.......	-	753	-	-	20	(1)	(1)
India, British..	349	29	8	71	509	465	951
Indochina 3/....	6,160	-	7/289	-	3	1	(1)
Italy...........	9,151	5,722	8,487	3,997	5,255	5,485	(1)
Japan...........	1,380	778	578	572	8/1,389	(1)	(1)
Madagascar 3/...	16,776	9,929	14,141	6,111	9,668	13,433	(1)
Mexico..........	3,059	4,340	5,699	3,521	9,480	9,611	9,815
Morocco:							
French 3/......	(1)	-	21	108	324	406	(1)
Spanish........	-	-	-	-	-	73	(1)
Norway..........	-	2	-	1,206	2,485	3,802	(1)
Spain...........	1,184	1,923	580	-	-	-	(1)
Sweden..........	101	1	-	-	52	48	165
Union of South Africa.........	64	50	51	53	63	54	59
U.S.S.R.	(1)	(1)	3,992	9/32,333	(1)	(1)	(1)
United States:							
Amorphous......	3,999	3,059	2,840	(10)	(10)	(10)	(10)
Crystalline....	4,494	1,672	2,133	(10)	(10)	(10)	(10)
Total 11/.	156,724	100,999	139,334	121,416	133,668	140,694	112,270

1/ Data not available.
2/ Less than 1 ton.
3/ Exports.
4/ Quantity not available; value reported as follows: 1935, $79,781; 1936, $88,812; 1937, $125,343; 1938, $41,590; 1939, data not available.
5/ Average based upon production of Bohemia and Moravia, which before 1918 formed part of Austria.
6/ Average based upon production of Lower Austria and Styria only. Data covering production of Bohemia and Moravia shown under Czechoslovakia.
7/ Concentrates.
8/ Average for 1935-36; data for 1937 not available.
9/ Average for 1932-34; data for 1930-31 not available.
10/ Bureau of Mines not at liberty to publish figures.
11/ Sum of figures given in table only; probably incomplete.

The softness and lustrous blackness of graphite make it an ideal constituent in pencil leads, and in fact its name is derived from a Creek word meaning "to write." In the United States, Mexican amorphous graphite is preferred for pencils, although some grades of Ceylon plumbago and Canadian graphite have been used successfully, alone or to tone mixtures with other kinds of graphite. The usual formula calls for 50 or less percent graphite, mixed with clay, and perhaps small percentages of stibnite and tallow or lampblack. In very soft pencils the amount of graphite used may be considerably more than 50 percent. Artificial graphite competes with the natural variety in this field.

Because of its inertness and opacity graphite may be employed in paints for the protection of bridges, railroad cars, smoke stacks, boiler fronts, tanks, metal roofs, and other exposed surfaces. Pure graphite is unsuitable as a paint pigment as it tends to coagulate in the oil vehicle and to spread under the brush into an excessively thin coating. On the other hand, impure graphite containing substantial quantities of silica can be mixed with iron oxide or zinc compounds to give a satisfactory pigment. In Michigan and elsewhere graphite rock has been ground directly into pigment, and the product often contains as little as 25 percent graphitic carbon.

Amorphous graphite, chiefly Korean and Mexican, is used in stove polishes. Carbon black may be added to improve the color, particularly if impure grades are used. Clay, rosin, soap, or asphalt may be used as a binder for the solid cake polishes; for the liquid polishes, gasoline, various oils, ammonia, or plain water are used as vehicles. In all cases the graphite has to be ground fine.

Carbon or graphite brushes have largely displaced all-metal brushes for electric generators and motors, providing better contact and reducing sparking. Metal gauzes filled with graphite were used formerly to increase conductivity but have been superseded by brushes made from compacted powders. In the United States artificial as well as amorphous graphite is employed in brushes, while in certain foreign countries brushes are said to contain Ceylon plumbago or flake graphite ground to 100-mesh. Ordinary carbon brushes, such as are used for general purposes, contain little or no graphite and are composed mainly of amorphous carbon, usually petroleum coke. Dry-battery carbons and numerous other electrical carbon products are similarly derived.

As the base of a boiler compound graphite may form a coating on the interior of the boiler pipes. Calcium and magnesium salts deposited in the pipes by hard water do not adhere to the flaky graphite film and may easily be flushed from the boiler system.

Graphite is mixed with the manganese dioxide in dry batteries to lower internal cell resistance. Crystalline flake, natural amorphous, and artificial amorphous grades have been used. This use of graphite reached a peak during the battery-radio era but declined with the advent of the A and B eliminator circuits. However, the growing popularity of portable radios and the shipments of flashlight cells to European black-out areas has rivived the demand for battery graphite.

Electrotyping graphite is very finely powdered and is ordinarily made from either very pure amorphous dust or artificial graphite. This material is used in two ways. First it is dusted upon the forms, which are polished so that the wax mold can be stripped clean, and then it is used once more for covering the mold, to form a conducting surface when the mold is immersed in the plating bath.

Either as a lubricant or simply as a filler graphite enters into steam and engine packings, hard-rubber compositions, hemp rope, wire rope and cable, and rubber valve disks. It is used as a dusting agent on certain kinds of prepared roofing to prevent sticking. The polishing of shot and the glazing of black and smokeless powder require a substantial amount of amorphous or dust graphite. One of the functions of the graphite used with explosives is to act as a lubricant, permitting the grains of explosive to flow freely without danger of spontaneous ignition. A somewhat similar use is for treating tea leaves and coffee beans. The graphite film is harmless and protects the products from moisture, in addition to improving color and general appearance. Graphite is used in the manufacture of cord and twine, in hat polishing, and as a filler or conditioner in fertilizers to coat the particles and prevent absorption of moisture. Polished slabs of clay and graphite are used to flatten window glass. Graphite has been used when sowing dusted pea seeds, as it does not affect the fungicidal action of the dusting material - copper oxide, for example - and prevents clogging and possible breaking of the drills used in planting.

Graphite is also used in brake linings, clutch facings, glass coloring, and radio resistors. A particularly pure grade is used in raising the carbon content of steel.

DOMESTIC CONSUMPTION

Although the consumption of natural graphite has fluctuated considerably during the past quarter century, definite trends are discernible. On the whole, less natural graphite is being used. The consumption of natural amorphous graphite has increased, but not enough to offset the decrease in use of crystalline graphite. The decline in crystalline graphite is reflected in the amount used in crucibles in 1913 and in 1938. In the year preceding the World War of 1914-18, 55 percent of the total graphite consumed went into the manufacture of crucibles, whereas just before the present war only 10 percent of the total was used in crucibles. During 1914-18 domestic crucible makers wanted principally Ceylon lump or chip plumbago, but in recent years they insist upon having Madagascar flake graphite of suitable mesh sizes. This trend is characteristic of the increasing interchangeability of the various kinds of graphite. If imports of one particular grade should cease, fairly satisfactory substitutions of other grades could be made in most instances. Some soft Ceylon lump is required for pencil-lead mixtures, and there are a few other specialties for which Madagascar flake or certain kinds of crystalline Ceylon graphite are desired in preference to qualities obtainable elsewhere. Fortunately, from the standpoint of national security, however, the tonnage of graphite that absolutely must be imported from these distant sources is a far smaller fraction of our total consumption today than it was 15 years ago, when these trends began to gain headway.

Original from THE OHIO STATE UNIVERSITY

TABLE 2.- Principal kinds and sources of graphite used in the United States

Commercial description	Principal uses	Customary sources	Consumption trend
A. Natural crystalline:			
1. Lump and chip 90% C.	Crucibles, ladles, stoppers, and retorts.	Ceylon, 100% (Minor deposit at Dillon, Mont.)	Diminishing.
2. Flake 85% C.	Crucibles, carbon brushes, foundry facings, lubricants, dry batteries.	Madagascar, 90% Canada, 5% Other, 5%	Fairly large, stationary
3. Dust 75% C.	Same as amorphous.	Ceylon, 60% Madagascar, 30% Other, 10%	Insignificant.
B. Natural amorphous: 90% C.	Foundry facings, core washes, pencils and crayons, lubricants, paints, shoe polish, dry batteries.	Mexico, 50% Chosen, 30% Canada, 10% Ceylon United States	Large, increasing.
C. Manufactured:			
1. Electrodes, etc. 95% C.	Electric furnaces.	United States, 100%	Do.
2. Powder 95% C.	Dry batteries, lubricants, commutator brushes, colloidal graphite.	United States and Canada, 100%	Fairly large, stationar

TABLE 3.- Graphite imported for consumption in the United States, 1936-40, by kinds

Year	Amorphous				Crystalline					
	Natural		Artificial		Lump and chip		Dust		Flake	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1936..........	20,160	$344,499	1,635	$63,804	251	$18,107	68	$4,090	2,057	$136,162
1937..........	25,354	512,162	802	31,562	482	41,499	321	17,600	2,634	149,492
1938..........	14,676	247,789	500	19,870	41	3,074	168	10,643	1,620	90,663
1939..........	18,675	269,046	413	15,383	1/	1/	1/602	1/30,421	2,260	110,476
1940..........	23,766	487,675	260	9,187	1/	1/	1/752	54,027	6,551	340,396

1/ Lump and chip included with dust.

TABLE 4.- Consumption of natural graphite in the United States, 1913, 1919, 1923, 1924, 1933, 1937, and 1938, by kinds of graphite and by uses.

Total consumption, short tons

	1913 1/	1919 2/	1923 2/	1924 2/	1933 3/	1937 4/	1938 4/
Amorphous graphite.........	6,500	12,500	29,500	26,500	5,813	21,000	12,100
Crystalline graphite.......	21,500	25,000	10,000	6,000	5,716	6,700	5,700
	28,000	37,500	39,500	32,500	11,529	27,700	17,800

Percentage of total consumption

Used for—							
Foundry facings, etc.	10	25	43.5	51.5	38.0	38.5	28.4
Lubricants, etc.	5	10	3.0	2.5	11.0	10.9	11.9
Pencils, crayons..........	10	5	9.0	5.0	12.0	10.6	9.7
Crucibles.................	55	45	15.0	13.0	17.5	8.3	10.0
Paints, stove polish, etc.	15	10	18.5	19.5	12.0	4.0	3.3
Commutator brushes........	-	-	8.5	5.0	3.5	.6	.8
Unspecified...............	5	5	2.5	3.5	6.0	5/27.1	5/35.9
	100	100	100.0	100.0	100.0	100.0	100.0

1/ Estimated by Geological Survey.
2/ Compiled by U. S. Tariff Commission; includes some artificial or manufactured graphite.
3/ Compiled by National Recovery Administration.
4/ Compiled from reports of consumers and dealers to the Bureau of Mines.
5/ Consumption in dry batteries amounted to 20.9 and 27.8 percent of the total in 1937 and 1938, respectively.

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PRICES AND MARKET REQUIREMENTS

Most purchases of foreign and domestic graphite are individual transactions based upon the type and quality of the lot in question, and because of the many varieties and grades it may be impossible to determine what material from a new source will be worth except by offering it to various buyers. This is not necessarily true, however, as regards a few established grades. Madagascar flake averaged about 5-7/8 cents a pound, delivered New York, duty paid May 1941. Hard, large, lump graphite from Ceylon was quoted in early 1941 at 8.6 cents a pound, c.a.f. New York. At Chosen, during the third quarter of 1940, flake-graphite prices ranged from $21.09 a long ton for crude Grade C, No. 2, to $107.81 for Grade A, while the price of amorphous fluctuated between $7.93 and $9.38 a ton. Mexican amorphous graphite, 80 to 82 percent carbon, was quoted at $10.60 a ton, f.o.b. Mexican shipping point, in 1940.

On the domestic market, according to Engineering and Mining Journal Metal and Mineral Markets for June 5, 1941, foreign grades, f.o.b. New York, were priced as follows:

> Per pound f.o.b. New York, Ceylon lump, 8 to 10 cents; carbon lump, 7 to 8 cents; chip, 5-3/4 to 6-3/4 cents; dust, 3-1/2 to 4 cents; Madagascar flake, 8 to 10 cents; prices nominal.
>
> No. 1 flake, 9 to 16 cents; No. 2, 7 cents; upward; fine ground, 55 to 70 percent carbon, 3 cents; upward; amorphous, 3-1/2 cents upward.
>
> Crude amorphous graphite, f.o.b. New York, $12 to $23 per ton, according to grade.

The majority of graphite buyers in the United States are reluctant to experiment with domestic grades, having long been accustomed to standard foreig material. Thus, even in the rare instances in which good natural graphite is found, commercial production must await discovery of a profitable market.

Crucible makers have individual specifications, but virtually all of the require Madagascar flake from recognized suppliers. A general specification for such material would call for virtually 100 percent between 14- and 48-mes and 75 percent through 28- and on 35-mesh. Carbon content ranges from 85 to 90 percent, and bulk density is such that 100 grams of the material will occu a minimum volume (after repeated jolting and tapping on a table top) of 129 c A 250-cc. cylindrical graduate was used in making this test, and readings wer taken at 2-minute intervals until constant within less than 1 cc.

Navy and Army specifications for lubricating graphite follow:

Navy Department Specification 14-G-4-b, 1922. Graphite, ground, amorpho Specifies percentage graphitic carbon and freedom from impurities; requiremen for fineness and inspection and testing.

Navy Department Specification 14-G-3e, 1934. Graphite, lubricating, fla Specifies grade, freedom from adulterations, ash content, percentage graphiti carbon, and size of flake.

United States Army Specification No. 2-64, 1927. Graphite. Gives requirements for grades, flake and amorphous; inspection and test methods; and packing requirements.

POSSIBILITIES FOR DOMESTIC GRAPHITE

Mill after mill has been erected to exploit new discoveries of domestic graphite without adequate consideration as to where or if the product could be sold at a remunerative price, and the final result always has been failure. Before the production of natural graphite is undertaken it is necessary to determine the type of material (whether amorphous or crystalline), the amount of graphitic carbon contained, the extent of the deposit, and the associated minerals. How the graphite can be used should also be determined and methods of beneficiation developed in accordance with the probable use of the product. Some domestic amorphous graphite is used in foundry facings and paints merely after grinding and screening, with little or no beneficiation or removal of associated impurities. On the other hand, the preparation of flake graphite is almost always complex. The crude flake and the associated minerals first must be crushed enough to free the graphite particles from the rock. The flake may then be separated from the gangue in one of several ways, of which froth flotation is likely to be most successful. The concentrate thus obtained may have to be refined further by grinding with rolls or buhrstone and screening, and perhaps by chemical treatment. The size of the flake is thus reduced, but this is more than offset by the greater purity of the material. However, if the flake is not strong enough to withstand the requisite cleaning operation and still leave a substantial percentage coarser than, say, 40-mesh, the concentrate can rarely be sold for more than $30 a ton, perhaps less.

GRAPHITE BUYERS

CALIFORNIA
Marshall Dill, 510 Montgomery St., San Francisco.
Pacific Graphite Works, 40th & Linden Sts., Oakland (amorphous or flake).

CONNECTICUT
American Crucible Co., Shelton.

ILLINOIS, CHICAGO
S. Obermayer Co., 2559 West 18th St. (crude).
Otley Paint Mfg. Co., 1742 N. Winchester Ave. (amorphous).
Superior Flake Graphite Co., 1531 First National Bank Building.

MASSACHUSETTS
Springfield Facing Co., Springfield (amorphous).

MICHIGAN
Cummings Moore Graphite Co., 1646 Green St., Detroit (amorphous, crystalline or Ceylon flake, artificial).

MINNESOTA
Forster Paint & Mfg. Co., Winona (amorphous, flake).

NEW JERSEY
American Lead Pencil Co., Hoboken.
Asbury Graphite Mills, Asbury (flake and powdered).
Bloomsbury Graphite Co., Bloomsbury (amorphous, flake).
Joseph Dixon Crucible Co., Jersey City.
J. H. Cantier & Co., 1-10 Greene St., Jersey City (amorphous, flake).

NEW YORK

- Garlock Packing Co., 250 Main St., Palmyra (ground).
- Ward's Natural Science Establishment Inc., 320 N. Goodman, Rochester.
- Williamson Graphite Co., 149 Columbia Heights, Brooklyn (ground and refined).
- NEW YORK CITY
  - American Cyanamid & Chemical Corporation, 30 Rockefeller Plaza.
  - H. J. Baker & Bro., 271 Madison Ave.
  - Barclay Chemical Co., Inc., 75 "A" Varick St.
  - Eagle Pencil Co., 703 East 13th St. (amorphous, flake).
  - Gerard-Kluyskens Corporation, 261 5th Ave.
  - Adolphe Hurst & Co., 328 West 42d St.
  - Ilsley Doubleday & Co., 229 Front St. (crude and ground).
  - International Selling Corporation, 70 Pine St.
  - Chas. Mathieu, Inc., 120 Liberty Ave.
  - Chas. Pettinos, 1 East 42d St. (all kinds)
  - Whittake Clark & Daniels, Inc., 245 Front St.

OHIO

- Hill & Griffith, 1265 State St., Cincinnati.
- Smith Facing & Supply Co., 1857 Carter Road, Cleveland (amorphous).

PENNSYLVANIA

- J. S. McCormick Co., 25th & A. V. Railroad, Pittsburgh.
- Paxson Co., Inc., 1206 Locust St., Philadelphia (amorphous or flake).
- Geo. F. Pettinois, Inc., 1206 Locust St., Philadelphia.
- Ross-Tacony Crucible Co., Robbins & Milnor, Philadelphia (flake).

DOMESTIC GRAPHITE PRODUCERS

ALABAMA

- Ceylon Graphite Co., Goodwater.

MICHIGAN

- Detroit Graphite Co., 550 12th St., Detroit. (mine at L'Anse).

NEVADA

- Carson Black Lead Co., Carson City.

NEW YORK

- Long Valley Ore Co., mine at Pope Mills, milling plant at Morristown.

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